High energy neutron Computed Tomography developed

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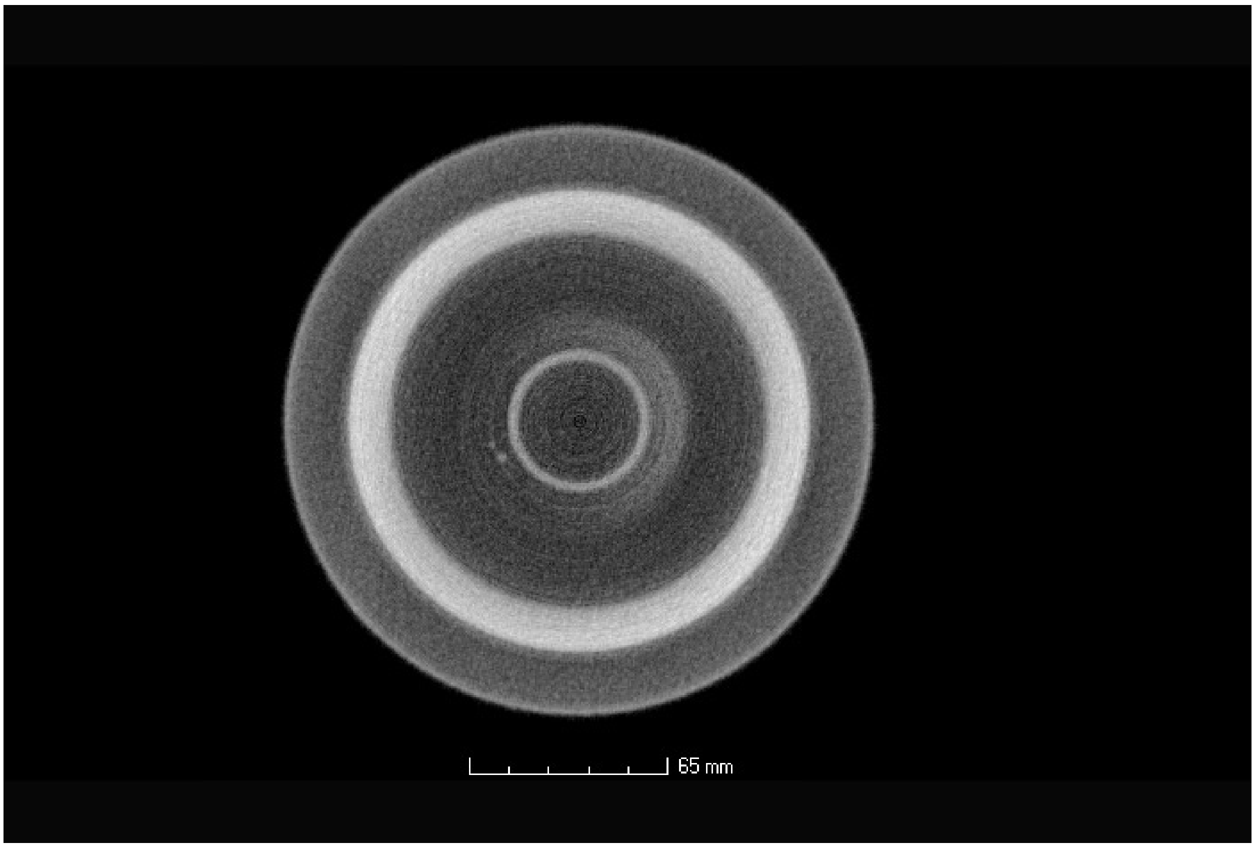

Researchers developed and demonstrated a unique high-energy neutron Computed Tomography (n-CT) capability at LANSCE/ Weapons Neutron Research (WNR) on Flight Path 15R. A collaboration between the Non-Destructive Testing and Evaluation Group (AET-6), LANSCE Nuclear Science (LANSCE-NS) and Lawrence Livermore National Laboratory (LLNL) enabled this achievement.

Significance of the work

Neutrons can complement X-rays for imaging due to their very different attenuation characteristics, which allow imaging of low atomic number (Z) materials through higher Z materials. For many years, most imaging has been performed with X-rays. However, X-rays are heavily attenuated when passing through dense materials, limiting their utility for imaging in some circumstances. This absorption increases strongly with atomic number, which hinders the ability of X-rays to view low-Z materials obscured by higher

Z materials. Moreover, X-ray scattering and detection characteristics at high energies make measurement of density profiles and buried feature detection difficult.

The National Institute for Science and Technology and Paul Scherrer Institute maintain thermal neutron (0.025 – 0.2 eV) imaging for thin items at their user facilities. However, higher-energy neutrons are required to penetrate thicker objects. LANL and LLNL obtained the first high-energy neutron images in the mid 1990s with imaging times on the order of 30-60 minute exposures per frame.

The Los Alamos and Livermore research collaboration has demonstrated a new high-energy neutron imaging capability at LANSCE/WNR using the “white” neutron source with neutron energies in the range from below 100 keV to over 600 MeV. (A “white” neutron source has equal power at all energies within a range). Each view is acquired in less than one minute. The team performed neutron computed tomography in which low-density material structures, such as polyethylene or foam, can be observed behind high-density materials, such as depleted uranium or tungsten. Comparison of the high-energy neutron computed tomography with tomography from a 15 MeV X-ray source revealed that n-CT enables much better observation of detailed structures obscured by the high-density materials. With completion of this demonstration, LANSCE now has a high-energy neutron imaging capability that can be deployed on WNR flight paths for unclassified and classified objects.

Research achievements

The team examined two sample complex objects to show the power of high-energy neutron radiography. In one example, a steel (top half), high-density polyethylene (bottom half) and foam (center teeth) phantom could be viewed through 76 mm of depleted uranium. Some ~ 3 mm diameter holes in the steel are visible. In the second example, the scientists conducted an 800-viewset n-CT experiment of a tungsten and polyethylene test object with 1, 2 and 3 mm tungsten carbide BBs in the inner ring. The 2 and 3mm BBs were readily visible. The researchers compared image slices taken from the n-CT reconstruction with an X-ray CT slice of the same object. Neutron imaging revealed the internal structure of the object, but the X-ray imaging does not show the same detail.The team

Researchers include James Hunter of Non-Destructive Testing and Evaluation Group (AET-6), Ron Nelson of LANSCE Nuclear Science (LANSCE-NS) and Jim Hall of Lawrence Livermore National Laboratory. The NNSA Enhanced Surveillance Campaign provided the primary funding for the work, and the Principal Associate Directorate for Technology and Engineering (PADSTE) supplied capability development funding via a Small Equipment Grant. The Readiness in Technical Base and Facilities program funds the LANSCE accelerator and neutron sources. This work supports the Lab’s Nuclear Deterrent and Global Security mission areas and the Nuclear and Particle Futures and Science of Signatures science pillars.

Caption for image below: Vertical slice of the test object.